https://doi.org/10.37045/aslh-2022-0003 Acta Silv. Lign. Hung., Vol. 18, Nr. 1 (2022) 41–56

Impact Assessment of Trunk Injection and Bark Treatment in Black Cherry (*Prunus serotina* Ehrh.) Control

Viktória Erzsébet HEGEDÉNÉ NEMES[a*] – Miklós MOLNÁR[b] – Ágnes CSISZÁR[a]

[a] Institute of Environmental Protection and Natural Conservation, University of Sopron, Sopron, Hungary
[b] Fehér-Rendszerház Informatikai Kft., Budapest, Hungary

Abstract – This invasive plant management study focuses on the treatment of younger and older seed-producing black cherry (*Prunus serotina* Ehrh.) individuals. We injected the older trees and applied bark treatment to the thinner saplings in 2018. Over two vegetation periods, we studied the effect of 11 herbicides and ranked the treatments based on their introduced foliage loss and sprouting. In the trunk injection experiment, the most effective treatment was a combination of glyphosate and clopyralid (Medallon Premium-Lontrel 300). Compositions without glyphosate did not meet expectations. In the bark treatment experiment, the herbicides used were combinations of glyphosate and MCPA (Medallon Premium Mecomorn-750 SL), glyphosate and dicamba (Medallon Premium-Banvel 480 S), and glyphosate and clopyralid (Medallon Premium-Lontrel 300). Results indicate that all three treatments are effective. Some of the technologies and chemical combinations this study presents are recommendable considering current plant protection legislation.

trunk injection / bark treatment / *Prunus serotina* / glyphosate / chemical control

Kivonat – A törzsinjektálás és törzskenés hatásának vizsgálata a kései meggy (*Prunus serotina* Ehrh.) elleni védekezés során. Növényvédelmi célú vizsgálatunkban magszóró, valamint fiatal kései meggy (*Prunus serotina* Ehrh). egyedek egyaránt kezelésre kerültek. Az idősebb fák injektálással, a vékony fiatal egyedek törzskenéssel való kezelése történt 2018-ban. Összesen tizenegy növényvédő szer hatását hasonlítottuk össze a két vegetációs időszakot felölelő kísérlet alatt, a kezelések a lombvesztés és a képződő sarjak alapján kerültek rangsorolásra. A törzsinjektálási kísérlet legeredményesebb kezelése a glifozát és klopiralid (Medallon Premium – Lontrel 300) kombinációja volt. A glifozátmentes szerek nem váltották be a hozzájuk fűzött reményeket. A törzskenés esetén az alkalmazott keverékek a glifozát és MCPA (Medallon Premium – Mecomorn 750 SL), a glifozát és dikamba (Medallon Premium – Banvel 480 S) valamint a glifozát és klopiralid (Medallon Premium – Lontrel 300) kombinációi voltak. Az eredmények alapján mindhárom kezelés sikeresnek tekinthető. A bemutatásra kerülő technológiák és szerkombinációk egy része a hatályos növényvédelmi jogszabályok figyelembevételével üzemi körülmények között is javasolhatók.

törzsinjektálás / törzskenés / *Prunus serotina* / glifozát / kémiai védekezés

[*] Corresponding author: viikii1991@gmail.com; H-6034 HELVÉCIA, Alsótelepi dűlő 5., Hungary

1 INTRODUCTION

Black cherry (*Prunus serotina* Ehrh.) was among the first species introduced to Europe from the Allegheny Plateau of the Appalachian Mountains in North America in the 17th century (Petitpierre 2008). According to Goeze (1916), black cherry appeared in Europe in 1629, while Wein (1930) states it was 1623. The first recorded occurrence in the Carpathian Basin was in 1897. Today, it is present in most European lowlands. The species was initially planted in the Netherlands (Van den Tweel – Eisjackers 1987) and Germany for fire protection and soil improvement purposes, typically on nutrient-poor sandy soils (Starfinger 1990, 1997; Muys et al. 1992, Starfinger et al. 2003, Kowarik 2010, Starfinger 2010, Terwei 2014). In its native environment, black cherry produces valuable lumber due to its extensive canopy and considerable height (Downey – Iezzoni 2000). It does not develop these attributes in European conditions (Petitpierre et al. 2009).

By the 1950s, foresters realized that black cherry had not met its expectations, and the damage the species caused quickly overshadowed the expected benefits (Muys et al. 1992). Kowarik (2010) provides a detailed analysis of the environmental and economic problems black cherry causes. The analysis states that dense canopies of black cherry inhibit the regeneration of native species. Black cherry reduces diversity in the herb layer due to its strong shading and the toxic cyanogenic glucosides (amygdalin, prunasin) found in its leaves and fruits (Schepker 1998, Brozdowski et al. 2021). Black cherry litter contains more nitrogen and other nutrients than the litter of most native European species (Vanderhoeven et al. 2005). This characteristic, combined with its observed allelopathic attributes (Csiszár 2009, Halarewicz et al. 2021), helps facilitate the spread of disturbance tolerant species by changing the nutrient composition of the soil (Chabrerie et al. 2008).

Black cherry seedling attributes include intense growth and strong sprouting ability (Marquis 1990). The intense growth and sprouting are due to its rootstock, which efficiently stores nutrients. Intense sprouting follows the felling of an adult tree; therefore, mechanical control methods rarely produce satisfying results (Annighöfer et al. 2012). The control method aims to destroy the root system, thereby eliminating the potential for sprouting. The trunk sprouting inherent in black cherry makes it hard to control the species. Uprooting and girdling are the most effective mechanical control methods. Due to the thick leaves, adhesives are advisable if chemical control becomes necessary (Csiszár – Korda 2017, Demeter – Lesku 2017).

Closed stands of black cherry increase the expenses of forest thinning, felling of diseased trees and end-use of forest stands by 40%. In addition, nurturing young forest stands can be ten times more expensive than usual (Borrmann 1988). A 2003 study assessed the damage caused by black cherry in German forests and reported annual crop failure and control costs of € 25 million (Reinhardt et al. 2003). Similar results appeared in the Netherlands (Olsthoorn – Van Hees 2002). Between 1997/1998 and 2007/2008, controlling black cherry in a biosphere reservation located in northern Italy accrued costs of 830,000 euros (Caronni 2008). The total cost of the various control methods of black cherry range from 150 to 1500 euro/ha/year. (Spaeth et al. 1994).

The main ingredient of the most frequently used herbicides to combat invasive plants in Hungary is glyphosate, and its use is always subject to authorization (Mihály 2017). Glyphosate has been in wide use since 1973, but in 2017, herbicides containing glyphosate were revised (Muys et al. 1992). Notwithstanding, in the same year, 18 members of the European Union (including Hungary) supported the authorization to use glyphosate for another five years. Nevertheless, enhanced analysis of glyphosate is overdue (Tosun et al. 2019).

This paper studied trunk injections, which – of all the chemical control methods in forestry – inflict the least damage on the environment. Properly executed bark treatment is also less polluting than the more commonly used spraying method. The herbicides studied in this experiment are reduced doses of successful mixtures previously used in 2016 (Nemes – Molnár 2017). The present study investigated the effectiveness of formulations devoid of glyphosate as well. The main goal of the experiment was to observe the effectiveness of the reduced doses to decrease the volume of herbicides released into the environment.

2 MATERIALS AND METHODS

2.1 Study site, location, and characteristics

We conducted the experiments in lands belonging to the Valkói Forestry of Pilisi Parkerdő Zrt. in the Gödöllő Hills forestry area of Hungary. The trunk injection experiment was performed in the Gödöllő 84/E (N – 47.56722, E – 19.36111); the bark treatment experiment was completed in the Gödöllő 84/C (N – 47.56111, E – 19.39944) forest subcompartments. These forest subcompartments are unmixed black locust (*Robinia pseudoacacia* L.) stands, in which black cherry manifests as an intensively spreading species. The mean annual precipitation level is 550-600 mm; the elevation of the forest subcompartment area of the experiments is 240-260 m. The mean annual temperature is 9.7 °C, and the annual sunlit hours are around 1,950 (OMSZ 2018). Neither forest subcompartment has any influx of water barring precipitation. According to the unified national soil type map (Pásztor et al. 2018), their soil types are humic sandy soils with surface soil depth between 60-90 cm (based on the forest subcompartments' description sheet).

Concerning climatic conditions, the second half of 2018 was a warm and dry season overall, with the second warmest autumn and the sixth warmest summer recorded in Hungary since 1901. There was a cold front at the beginning of October; otherwise, the mean temperature from July to December was higher than in most previous years. Heavy rainfall occurred on July 23, 2018 (over 6 mm mean for Hungary). Conversely, August was very dry, September was average, and the mean precipitation in October was far below average. Barely any rain fell in the first half of November. Humidity was higher in July, but from August to November, it was drier, while December was around the same humidity wise compared to the average of 1981-2010. (OMSZ 2018).

2.2 Selection of trees

We selected trees for the injection experiment according to two criteria:

1. The diameter at breast height (DBH) of trees must be above 5 cm, but most of the selected trees had diameters above 12 cm diameter at breast height.
2. The trees had to be healthy and full of foliage, especially the crowns.

Table 1 displays the mean diameter of the selected trees (with deviation) for the summer application of each treatment. *Table 2* contains the same information for autumn applications. Based on Kraft's crown class (Smith et al. 1997), the tables also exhibit the position distribution of treated trees in the canopy. The trees were between an estimated 20 and 30 years of age.

Table 1. The biometric parameters of the injected trees of experiment conducted on July 25

Treatment	Mean diameter at breast height (cm)	Deviation	Crown class (Kraft)			
			D	CD	I	S
1.	13.6	5.1		2	1	7
2.	12.9	5.3		6		4
3.	18.3	4.3	1	9		
4.	15.5	5.4		9		1
5.	12.1	5.5		7	1	2
6.	15.5	2.3		10		
7.	17.4	4.0		10		
8.	18.3	5.9		6	1	3
9.	18.5	8.9		7		3
10.	16.5	5.2		8	1	1
11.	19.8	4.6		9		1

Abbreviations: For Crown class: D = Dominant, CD = Codominant, I = Intermediate, S = Suppressed. The numbers in the "Crown class (Kraft) column display the number of trees that fall into each category by each treatment. For treatments see *Table 5*.

Table 2. The biometric parameters of injected trees of the experiment conducted on Sept. 15

Treatment	Mean diameter at breast height (cm)	Deviation	Crown class (Kraft)			
			D	CD	I	S
1.	13.4	7.1		2		8
2.	19.4	12.6	1	5	1	3
3.	15.5	8.1	1	3		6
4.	12.8	6.5		4		6
5.	18.6	8.6	1	8		1
6.	16.8	6.4		2	1	7
7.	16.6	5.0		5	2	3
8.	15.9	9.3		3	2	5
9.	14.3	6.8		2	1	7
10.	14.5	7.4		2	1	7
11.	15.3	6.0		2	1	7

Abbreviations: For Crown class: D = Dominant, CD = Codominant, I = Intermediate, S = Suppressed. The numbers in the "Crown class (Kraft) column display the number of trees that fall into each category by each treatment. For treatments see *Table 5*.

For the bark treatment experiments, we selected trees according to one criteria: They had to be healthy and have intact foliage. The trees on that plot were similar, but most black cherry specimens were healthy. *Table 3* and *Table 4* list the treated tree diameters for the summer and autumn application respectively. We estimated the trees were around 5–8 years old.

Table 3. Mean diameter at breast height (cm) of treated trees of the experiment conducted on July 25

Treatment	Mean diameter at breast height (cm)	Deviation
1.	4.3	1.2
2.	4.5	1.1
3.	4.6	1.1

For treatments see *Table 6.*

Table 4. Mean diameter at breast height (cm) of treated trees of the experiment conducted on September 15

Treatment	Mean diameter at breast height (cm)	Deviation
1.	4.4	1.2
2.	4.6	1.2
3.	4.7	1.2

For treatments see *Table 6*.

2.3 Applied treatments and herbicides

We chose the herbicides and doses based on our previous experiences with projects that included defence against black cherry (Nemes 2015, Nemes – Molnár 2017), and on the recommendations of invasive plant management specialists who previously used part of these products (Demeter – Lesku 2017, Verő – Csóka 2017).

We performed the experiments on July 25, 2018, and on September 15, 2018. We applied 11 treatments during the trunk injection experiment (*Table 5*) on two occasions. We injected the trunks of 10 specimens on both occasions. We treated 220 specimens in total.

During the trunk injection experiment, we treated trees with formulations and the mixtures listed in *Table 5*. All treatments were 55% concentration aqueous solutions, except for the eighth treatment. Medallon Premium, the main herbicide used in this experiment, is widely used in forest plant protection. Consequently, we tested this herbicide by itself as the first treatment. In treatments 2–5, we mixed Medallon Premium with other components (Mecomorn 750 SL, Banvel 480 S, Lontrel 300, Tomigan 250 EC). We added formulations containing good quality translocating ingredients to the mixtures. One of the components of the eighth treatment contained glyphosate but also consisted of a 2.4-D active substance.

Table 5. Used herbicides during injection

Treatment	Formulation	Dosage	Active substance
1.	Medallon Premium	55%	480 g/l glyphosate
2.	Medallon Premium Mecomorn 750 SL	50% 5%	480 g/l glyphosate 750 g/l MCPA
3.	Medallon Premium Banvel 480 S	50% 5%	480 g/l glyphosate 480 g/l dicamba
4.	Medallon Premium Lontrel 300	50% 5%	480 g/l glyphosate 300 g/l clopyralid
5.	Medallon Premium Tomigan 250 EC	50% 5%	480 g/l glyphosate 36% fluroxypyr
6.	Chikara Duo	55 %	6.7 g/kg flazasulfuron + 288 g/kg glyphosate
7.	Kyleo	55%	160 g/l 2.4 D + 320 g/l glyphosate
8.	Kyleo Mezzo 20 WG	40% 1%	160 g/l 2.4 D + 320 g/l glyphosate 20% metsulfuron-methyl
9.	Mecomorn 750 SL	55%	750 g/l MCPA
10.	Banvel 480 S	55%	480 g/l dicamba
11.	Lontrel 300	55%	300 g/l clopyralid

The bark treatment experiment had three treatments (*Table 6*), and we performed this experiment two times. We applied each treatment to 15 tree specimens both times and treated 90 specimens in total. Formulations and mixtures used in the bark treatment were reduced doses of what we utilized in the trunk injection experiment. Contrary to a previous experiment (Nemes – Molnár 2017), we did not use linseed oil as a solvent but chose lesser viscosity water instead.

Table 6. Used herbicides during bark treatment

Treatment	Formulation	Dosage	Active substance
1.	Medallon Premium Mecomorn 750 SL	30% 3%	480 g/l glyphosate 750 g/l MCPA
2.	Medallon Premium Banvel 480 S	30% 3%	480 g/l glyphosate 480 g/l dicamba
3.	Medallon Premium Lontrel 300	30% 3%	480 g/l glyphosate 300 g/l clopyralid

We drilled multiple holes (2–5, depending on the treated tree's diameter at breast height) 5 centimetres apart into the thicker, bearing specimen trunks at breast height. The hole diameters were 6 millimetres, their depth was 2.5 centimetres, and their angle was 45° degrees. We injected 1 ml of each formulation directly into the sapwood, after which we closed the holes with silicone acetate to prevent leaching and evaporation.

Three people executed the injection. The first person drilled the holes; the second person injected the formulations; the third person plugged the holes using a caulking gun. Treating a tree took no more than one minute and ensured minimal mixture evaporation. We marked injected trees with an airbrush for subsequent identification. We evaluated the injected trees and observed the damage inflicted on the injected specimens.

The experiment treated 2–5 cm-thick young trees with heights between 2–3 m. Procedure execution consisted of treating the full girth of the trees with the formulations 1 m above ground clearance in 30–40 cm wide lines. We used a brush to apply the formulations.

2.4 Evaluation of treatment efficiency

We classified the tested technologies that resulted in the destruction of black cherry – both the above and underground parts – as successful. Foliage loss determined the aboveground destruction. We examined the colour change and drying of the foliage in the total ratio of the tree crown and assessed foliage loss visually without considering the leaves on the emerging sprouts.

To demonstrate the drying of foliage, we used a scale ranging from 1 to 10 (*Table 7*). Although EPPO's (2014) phytotoxicity assessment standard influenced our thought process, we created the scale mostly from our own experiences. We wanted to demonstrate the phytobiological effects of the applied herbicides at a deeper level than just foliage loss and created the values for statistical comparison. We chose the 1–10 scale to make comprehension easily accessible and comprehensible. We distinguished between brown and dry foliage based on the water content of the tissues; leaves deemed as brown had much higher water content than dry leaves. The foliage of each treated specimen was assessed separately. The values were weighted based on the percentage of the foliage representing each condition. We then added up the observed conditions. For example, if one injected tree had foliage that was 40% yellow but 60% was visibly completely dry, it would have a value of 6.7, based on this calculation: $0.4 \times 4 + 0.6 \times 8.5 = 6.7$.

Table 7. The scale created to demonstrate the efficiency of the treatments

Value	Foliage condition
1	Foliage is 100% green, undamaged and viable
4	Foliage is 100% yellow
7	Foliage is 100% brown
8.5	Foliage is completely dry
10	Total foliage loss

We could infer the degree of the root destruction by reduced re-sprouting ability and sprout vitality; an absence of sprouts indicated destruction.

We conducted two-week evaluations of the experiment we conducted on July 25, 2018. These evaluations lasted until October 8, 2018. The experiment conducted on September 15, 2018, was assessed on September 29, 2018, which was the only assessment during the vegetation period. The evaluations stopped on these dates to avoid misidentifying loss of foliage due to the treatments for winter abscission of foliage. We assessed both experiments once more on May 5, 2019, in the following vegetation season. We rated the treatments based on foliage condition and the number of sprouts that appeared by May 5, 2019. We did not measure sprouts that treated trees produced because every injected tree produced them in such a great quantity (over 20/tree, estimated) and quality (over 40 cm height/sprout, estimated). Nonetheless, we assumed the sprouts were not only sufficient to ensure the survival of the treated tree but also concluded that they actively furthered the colonization of black cherry. We did not calculate final foliage loss during 2018 but completed observations on May 5, 2019.

To reveal the differences between each treatment regarding leaf loss alone, we evaluated the results via non-parametric ANOVA (Kruskal-Wallis test) ($P < 0.05$) based on the foliage loss observed on May 5, 2019 (InStat 2003).

3 RESULTS

3.1 Results of the trunk injection experiment

We compared the results of the injection experiment. The Kruskal-Wallis test did not show a significant difference between the formulations containing glyphosate ($P>0.05$, $KW = 169.03$). However, there was a disparity between the herbicides containing glyphosate and those that did not. Significant distinction occurred between concoctions including glyphosate and Mecomorn 750 SL ($P < 0.05$, $KW = 169.03$), and an extremely significant difference appeared between glyphosate mixtures, and Banvel 480S, Lontrel 300 ($P < 0.001$, $KW = 169.03$) as well.

There was no contrast between Mecomorn 750 SL and Banvel 480S ($P > 0.05$, $KW = 169.03$), but there was an extremely significant difference between Mecomorn 750 SL and Lontrel 300 ($P < 0.001$, $KW = 169.03$), and an enormous difference between Banvel 480S and Lontrel 300 ($P < 0.01$, $KW = 169.03$).

Figure 1 shows the effect of each herbicide applied on July 25, 2018. *Figure 2* exhibits the effect of the formulations of *Figure 1* that did not stimulate sprouting. *Figure 3* contains the effect of the herbicides of the second application. *Figure 4* shows those herbicides in *Figure 3* that did not trigger sprout production.

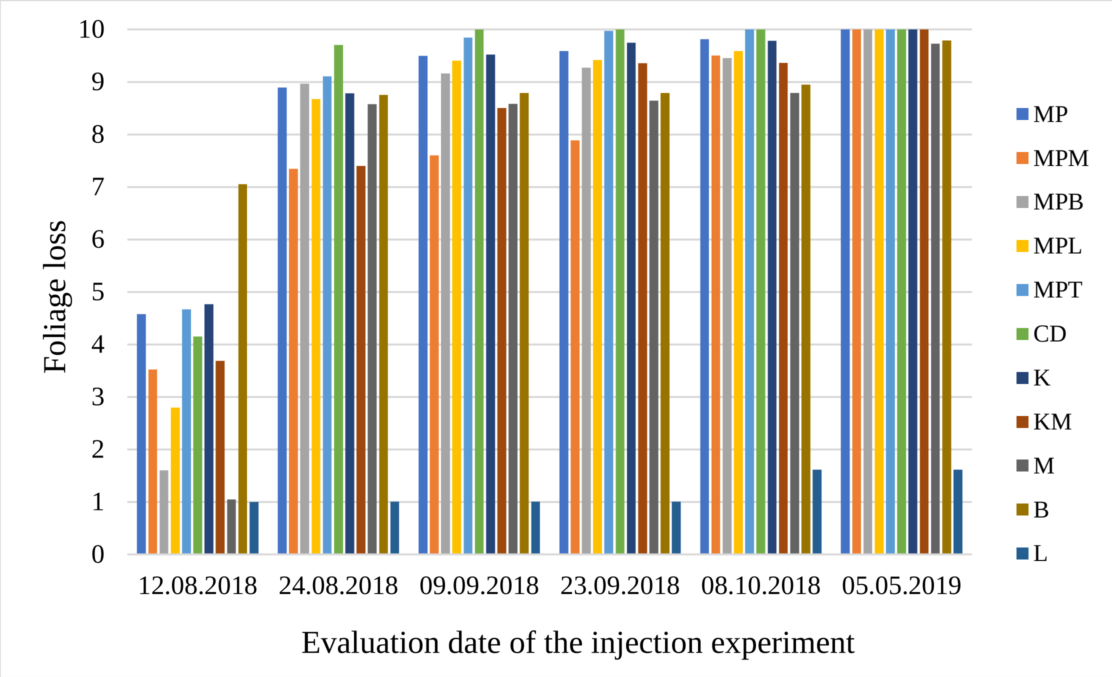

Figure 1. Effectiveness of formulations used in the trunk injection experiment conducted on July 25. MP: Medallon Premium, MPM: Medallon Premium - Mecomorn 750 SL, MPB: Medallon Premium - Banvel 480 S, MPL: Medallon Premium - Lontrel 300, MPT: Medallon Premium - Tomigan 250 EC, CD: Chikara Duo, K: Kyleo, KM: Kyleo – Mezzo 20 WG, M: Mecomorn 750 SL, B: Banvel 480 S, L: Lontrel 300

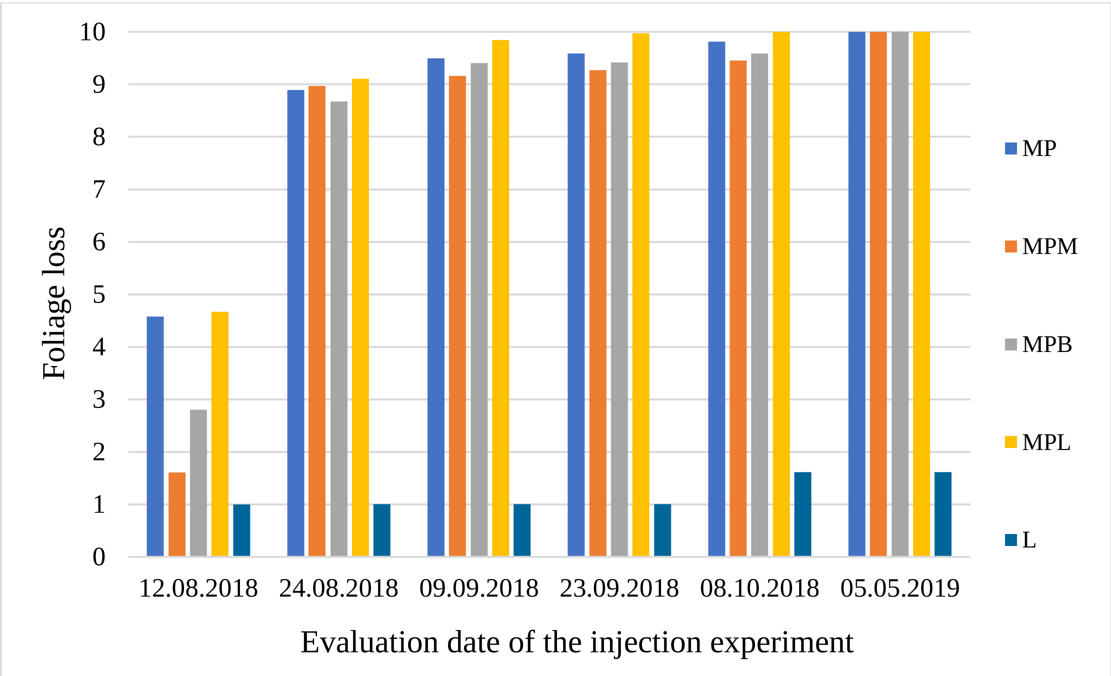

Figure 2. Effectiveness of the formulations used in the trunk injection experiment conducted on July 25 that did not stimulate sprouting. Abbreviations: see Figure 1.

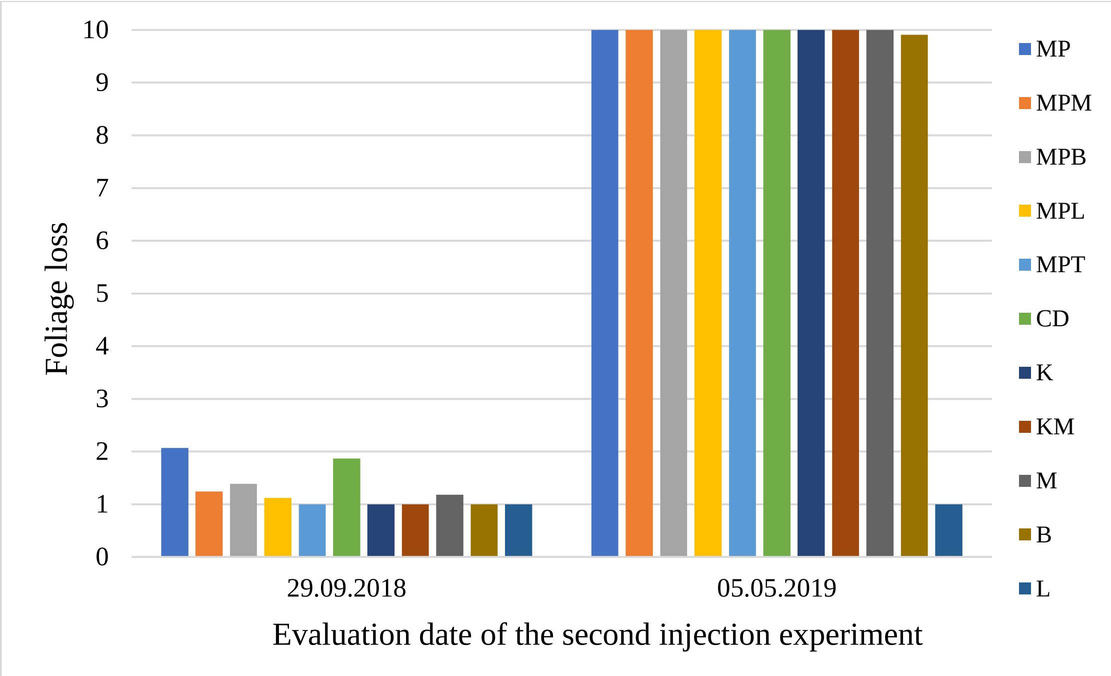

Figure 3. Effectiveness of formulations used in the trunk injection experiment conducted on September 15. Abbreviations: see Figure 1.

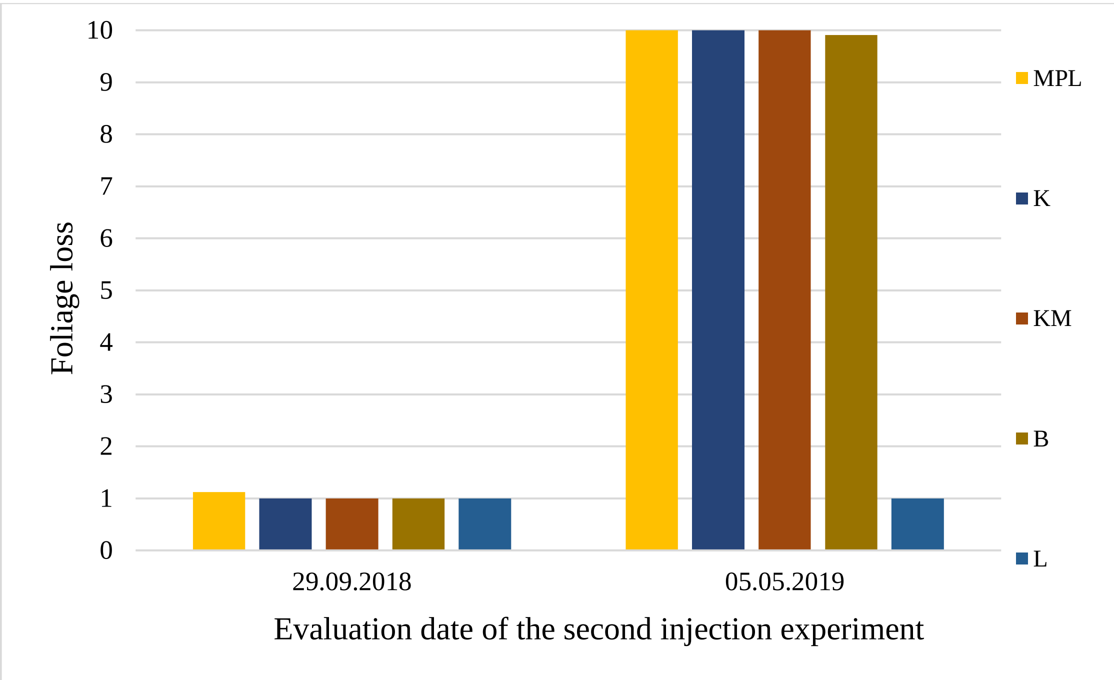

Figure 4. Effectiveness of the formulations used in the second trunk injection experiment conducted on September 15, that did not stimulate sprouting. Abbreviations: see Figure 1.

Table 8 ranks the formulations based on induced foliage loss and sprout stimulation. The values of the final date in the table are the mean of both the first and second trunk injection experiment.

Overall, the best mixture was the 50–5% aqueous solution of Medallon Premium – Lontrel 300 (480 g/l glyphosate-300 g/l clopyralid) combination, which was effective when applied in both summer and autumn. Moreover, it stimulated no sprouting in either case.

The following three treatments could potentially be applied in summer without stimulating sprouting. Ranked from best to worst, these include Medallon Premium-Tomigan 250 EC (480 g glyphosate-36% fluroxypyr), Medallon Premium (480 g glyphosate), and Medallon Premium-Banvel 480 S (480 g/l glyphosate-480 g/l dicamba).

The following three combinations could be applied in autumn without stimulating sprouting. From best to worst, these were Kyleo (160 g/l 2.4-D + 320 g/l glyphosate), Kyleo – Mezzo 20 WG (160 g/l 2.4-D + 320 g/l glyphosate-20% metsulfuron-methyl), and Banvel 480 S (480 g/l dicamba).

The following four treatments were unsuccessful. The first three stimulated sprouting, and the fourth had an insufficient effect on foliage loss: Chikara Duo (6.7 g/kg flazasulfuron + 288 g/kg glyphosate), Medallon Premium – Mecomorn 750 SL (480 g/l glyphosate-750 g/l MCPA), Mecomorn 750 SL (750 g/l MCPA), and Lontrel 300 (300 g/l clopyralid).

Table 8. The effectiveness of each treatment of the injection experiment according to the foliage loss and sprouting, ranked from best to worst

	Evaluation of the injection according to the foliage loss						Sprouting	
Treatment	201.8. 8.12	2018.08.24	2018.09.09	2018.09.23	2018.10.08	2019.05.05	1st application	2nd application
MP- Lontrel 300	2.8	8.7	9.4	9.4	9.6	10.0	-	-
MP - Tomigan 250 EC	4.7	9.1	9.8	10.0	10.0	10.0	-	Yes
MP	4.6	8.9	9.5	9.6	9.8	10.0	-	Yes
MP - Banvel 480 S	1.6	9.0	9.2	9.3	9.5	10.0	-	Yes
Kyleo	4.8	8.8	9.5	9.7	9.8	10.0	Yes	-
Kyleo - Mezzo 20 WG	3.7	7.4	8.5	9.4	9.4	10.0	Yes	-
Banvel 480 S	7.1	8.8	8.8	8.8	9.0	9.9	Yes	-
Chikara Duo	4.2	9.7	10.0	10.0	10.0	10.0	Yes	Yes
MP - Mecomorn 750 SL	3.5	7.3	7.6	7.9	9.5	10.0	Yes	Yes
Mecomorn 750 SL	7.1	8.8	8.8	8.8	9.0	9.9	Yes	Yes
Lontrel 300	1.0	1.0	1.0	1.0	1.6	1.3	-	-

Abbreviations: MP: Medallon Premium. Foliage loss were calculated according to *Table 7.*

3.2 Results of the bark treatment experiment

In the bark treatment experiment, combinations Medallon Premium-Mecomorn 750 SL, Medallon Premium-Banvel 480 S initially showed better results than the Medallon Premium-Lontrel 300 formulation (*Figure 5*). Loss of foliage proceeded faster in the first two treatments mentioned above, and there was visible drying during the second evaluation in August. While in the case of Medallon Premium-Lontrel 300 mixture, the rate of foliage loss was slower and strong green shoots were present.

However, at the final evaluation, we observed that all three treatments resulted in total loss of foliage, and only one of 15 trees treated with Medallon Premium-Mecomorn 750 SL produced two sprouts. Therefore, we derived that all three treatments can be considered successful.

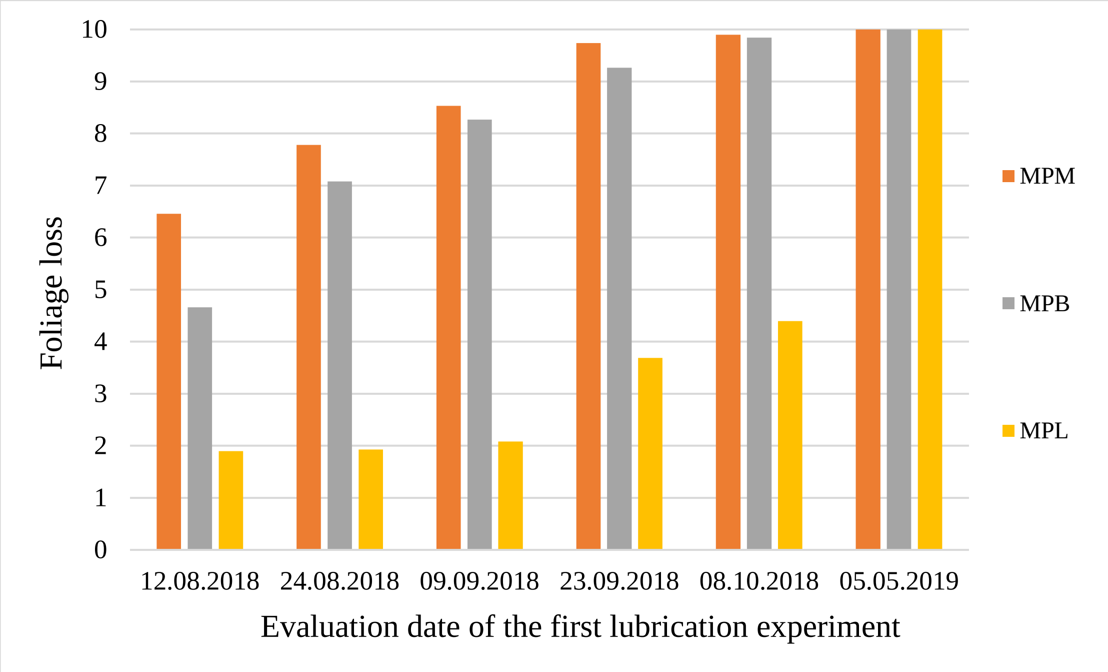

Figure 5. Effectiveness of formulations used in the bark treatment experiment conducted on July 25. Abbreviations: see Figure 1.

The second iteration of the experiment greatly resembled the first one detailed above (*Figure 6*), but no sprouts appeared this time.

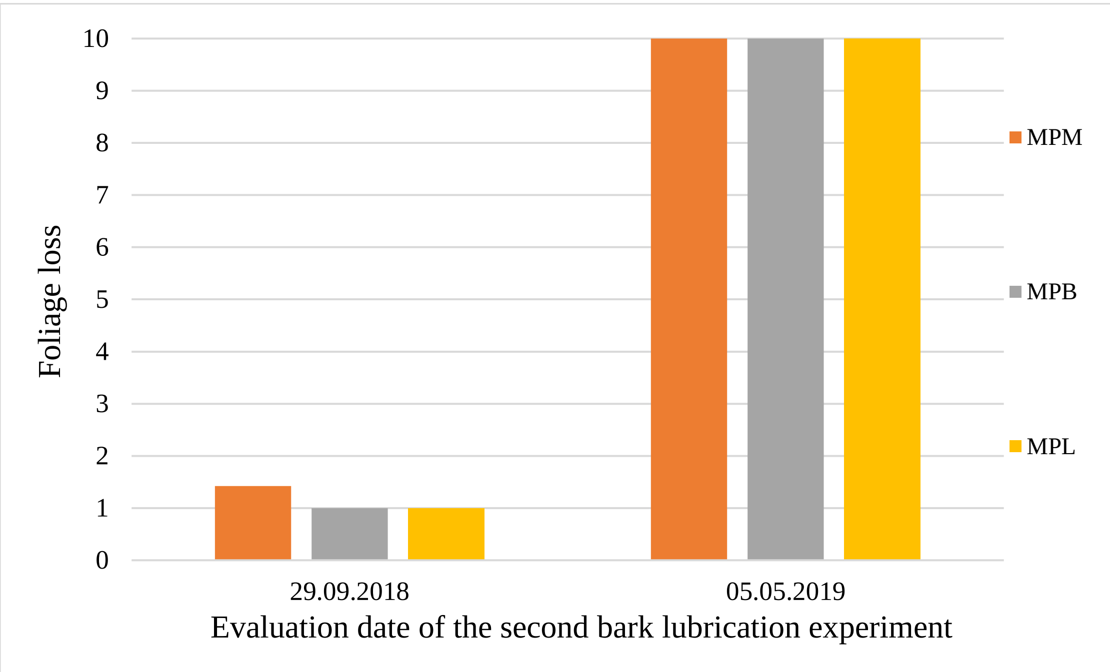

Figure 6. Effectiveness of formulation used in the bark treatment experiment conducted on September 15. Abbreviations: see *Figure 1.*

All treated trees were leafless and virtually sprout-less (see above) at the final evaluation. Consequently, there was not much point in conducting a Kruskal-Wallis test as we did in the trunk injection experiment.

4 DISCUSSION

The most commonly used procedure to suppress black cherry is the cut-stump method, in which after the felling of black cherry, herbicides are applied in an attempt to inhibit its growth (Lemmens – Tol 1977; Brehm 2004; Vanhellemont et al. 2008). Otręba et al. (2017) found this method ineffective. However, they found mechanical girdling to be an effective method.

Not all treatments were successful in the trunk injection experiment. The differences manifested in the time needed to show effects and the influence on sprouting ability. The formulations tested were not always fruitful in their respective doses. Nevertheless, those that were effective could potentially be used in practice, especially the combination of glyphosate and clopyralid (Medallon Premium-Lontrel 300). The combinations whose applications resulted in intense sprouting despite the destruction require attention; the season of planned application needs to be considered to avoid the undesirable sprouting response (*Table 8*). The soil was moderately fertile, but on weaker soils, there would be potentially less sprouting response because the trees would have fewer reserve nutrients stored. The reverse applies to soils that are more fertile. One of the most important aspects of all control methods is their effect on the environment, which entails that we need to favour mechanical methods whenever possible. However, mechanical methods do not always yield the outcomes expected of them in practice. According to a Polish experiment (Otręba et al. 2017), girdling – which is the most successful mechanical method – only destroyed 24–54% of treated trees. A Belgian study calls attention to the varying efficiency of mechanical methods, citing that even though biological methods can be very successful, the reliability of these methods drops off compared to chemical methods (Van Den Meersschaut – Lust 1997). Moreover, executing biological methods properly requires great expertise. Wronska-Pilarek et al. (2022) emphasise that chemical control is successful in reducing inflorescence size and number. Mechanical methods are always preferred in nature conservation areas because glyphosate and other chemicals endanger valuable local flora. Still, it is important to clarify the minimum effective doses of each chemical because in the areas where chemical control is unavoidable, it must be done in the gentlest way possible.

Glyphosate-based herbicides are the mostly widely used herbicides worldwide and in Hungary. Their use is always subject to authorization (Mihály 2017). Opinions regarding glyphosate differ, and its toxicity is controversial. Rolando et al. (2017) has found that glyphosate-based herbicides applied correctly in a prescribed manner cause no significant concerns for humans, land, or aquatic fauna. In contrast, in their systematic literature review, Brovini et al. (2021) concluded that glyphosate represents a high risk to aquatic environments when applied at the concentrations permitted by the legislation of some countries. Another study found that the reported toxic effects are not from the glyphosate itself, but originate from the petroleum-based oxidized molecules (POEA) (Defarge et al. 2018). However, Van Bruggen et al. (2018) have warned that while the acute toxic effects of glyphosate are low, exposure to chronic, ultra-low doses due to its accumulation in the environment has significant environmental risks. Even though their critical review does not attribute a clear and unambiguous harmful effect to glyphosate, Torretta et al. (2018) have argued that glyphosate use should be reduced.

The experiment with reduced dosage was not as conducive as we had hoped for ecological and economic reasons. Overall, we found both trunk injection and bark treatment to be effective control methods, viable to use after a meticulous risk assessment, reinforcing previous literature (Csiszár – Korda 2017; Demeter – Lesku 2017, Nemes – Molnár 2017, Verő – Csóka 2017).

All three formulations were efficient in the bark treatment experiment; they all resulted in 100% destruction of the treated specimens. There were some differences in their effect-causation process. An important result is that even though there was no mechanical pre-treatment, all treated trees were still destroyed. We can conclude that bark treatment using the appropriate formulations and a simple paintbrush is sufficient. This is noteworthy concerning the method process because bark treatment is easier and faster than injection.

5 CONCLUSIONS

Our results confirm that trunk injection and bark treatment can be effective control methods when executed with herbicides that do not stimulate sprouting. These results accord with the results of earlier studies (Demeter – Lesku 2017, Nemes – Molnár 2017, Verő – Csóka 2017). Mechanical methods are still preferable whenever possible, but these methods are not always effective. Moreover, biological methods are often uncertain, even when executed with great care and knowledge. Since most habitats include young, middle-aged, and old trees simultaneously, using all three control methods carefully would be ideal to minimize environmental impact yet yield good results. In areas where control of black cherry is unsuccessful barring the application of herbicides, knowledge of minimum effective doses is essential to minimize potential negative effects on the environment.

Due to significant sprouting, we believe that conducting further experiments regarding dose reduction in stands of similar habitats holds no benefit. Even when the seed-producing specimens were destroyed, the destruction was accompanied by vigorous sprouting, which created a problem tantamount to the one we were trying to solve. In our case, the sprouts were abundant and vigorous enough to ensure the further spread of the species.

Formulations containing glyphosate showed significantly better results than formulations that did not contain the substance. However, one treatment which did not have glyphosate as its active component, Banvel 480 S (480 g/l dicamba), was successful when applied in autumn. Further experiments could focus on this treatment to study its effectiveness because if it is effective, it could be used instead of glyphosate.

Treating the bark of young trees or individuals with a thin trunk using a brush is sufficient to ensure extermination. This is an important result because a simple technology such as just drawing lines with a brush alone can treat more trees over the same course of time as opposed to making a wound on a tree in addition before applying the herbicide with a brush.

Acknowledgements: We would like to thank István Hegede for his help in executing the experiments in the field. We would like to express our gratitude to all associates of Valkói Forestry of Pilisi Parkerdő Zrt. who permitted the experiment to take place and provided the necessary environment for the creation of the formulations.

REFERENCES

ANNIGHÖFFER, P. – SCHALL, P. – KAWALETZ, H. – MÖLDER, I. – TERWEI, A. – ZERBE, S. – AMMER, C. (2012): Vegetative growth response of black cherry (*Prunus serotina*) to different mechanical control methods in a biosphere reserve. Canadian Journal of Forest Research 42 (12): 2037-2051. https://doi.org/10.1139/cjfr-2012-0257

BORRMANN, K. (1988): Ausbreitung und rationelle Bekämpfung der spätblühenden Traubenkirsche (*Prunus serotina*). [Spread and rational control of black cherry (*Prunus serotina*).] Socialistiche Forstwirtschaft 38: 366-371. (in German)

BREHM, K. (2004): Erfahrungen mit der Bekämpfung der Spätblühenden Traubenkirsche (*Prunus serotina*) in Schleswig-Holstein in den Jahren 1977-2004. [Control of black cherry (*Prunus serotina*) in Schleswig-Holstein from 1977-2004.] In: LÜTT, S. (ed.): Neophyten in Schleswig-Holstein: Problem oder Bereicherung? Dokumentation einer Tagung im LANU am 31.03.2004. [Neophytes in Schleswig-Holstein: problem or enrichment? Documentation of a conference in

LANU on March 31, 2004.] Ministerium für Landwirtschaft, Umwelt und ländliche Räume des Lander Schleswig-Holstein, Kiel, Germany. 66-78. (in German)

BROVINI, E.M. – CARDOSO, S. J. – QUADRA, G.R. – VILAS-BOAS, J.A. – PARANAÍBA, J.R. – DE OLIVEIRA PERIRA, R. – MENDONCA, R.F. (2021): Glyphosate concentrations in global freshwaters: are aquatic organisms at risk? Environmental Science and Pollution Research 28: 60635-60648. https://doi.org/10.1007/s11356-021-14609-8

BROZDOWSKI, J. – WALISZEWSKA, B. – LOFFLER, J. – HUDINA, M. – VEBERIC, R. – MIKULIC-PETKOVSEK, M. (2021): Composition of Phenolic Compounds, Cyanogenic Glycosides, Organic Acids and Sugars in Fruits of Black Cherry (*Prunus serotina* Ehrh.). Forests 2021 12: 762. https://doi.org/10.3390/f12060762

CARONNI, F.E. (2008): Il caso del ciliegio tardivo (*Prunus serotina* Ehrh.) al Parco lombardo della Valle del Ticino. [The case of Black Cherry (*Prunus serotina* Ehrh.) at "Parco lombardo della Valle del Ticino".] In: GALASSO, G. – CHIOZZI, G. – AZUMA, M. – BANFI, E. (eds.): Le specie alloctone in Italia: censimenti, invasività e piani di azione. [Alien species in Italy: censuses, invasiveness and action plans.] Memorie della Societa Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 36: 37-38. (in Italian)

CHABRERIE, O. – VERHEYEN, K. – SAGUEZ, R. – DECOCQ, G. (2008): Disentangling relationships between habitat conditions, disturbance history, plant diversity, and American black cherry (*Prunus serotina* Ehrh.) invasion in a European temperate forest. Diversity and Distribution 14: 204-212. https://doi.org/10.1111/j.1472-4642.2007.00453.x

CSISZÁR, Á. (2009): Allelopathic effects of Invasive Woody Plant Species in Hungary. Acta Silvatica et Lignaria Hungarica 5: 9-17. https://aslh.nyme.hu/fileadmin/dokumentumok/fmk/acta_silvatica/cikkek/Vol05-2009/01_csiszar_p.pdf

CSISZÁR, Á. – KORDA, M. (2017): Summary of invasive plant control experiments. In: CSISZÁR, Á. – KORDA, M. (eds.): Practical experiences in invasive alien plant control. Duna–Ipoly National Park Directorate, Budapest. 205-241.

DEFARGE, N. – SPIROUX DE VENDÔMOIS, J. – SÉRALINI, G.E. (2018): Toxicity formulants and heavy metals in glyphosate-based herbicides and other pesticides. Toxicology Reports 5: 156-163. https://doi.org/10.1016/j.toxrep.2017.12.025

DEMETER, L. – LESKU, B. (2017): Eradication of invasive alien plants in the southern Nyírség area of the Hortobágy National Park Directorate. In: CSISZÁR, Á. – KORDA, M. (eds.): Practical experiences in invasive alien plant control. Duna–Ipoly National Park Directorate, Budapest. 79-84. https://oakprotection.eu/en/rosalia-handbooks-3-practical-experiences-invasive-alien-plant-control

DOWNEY, L.S. – IEZZONI, F.A. (2000): Polymorphic DNA Markers in Black Cherry (*Prunus serotina*) Are Identified Using Sequences from Sweet Cherry, Peach, and Sour Cherry. Journal of the American Society for Horticultural Science 125 (1): 76-80. https://doi.org/10.21273/JASHS.125.1.76

EPPO (2014): PP 1/135 (4) Phytotoxicity assessment – Efficacy evaluation of plant protection products. OEPP/EPPO Bulletin 44 (3): 265-273. https://doi.org/10.1111/epp.12134

GOEZE, E. (1916): Liste der seit dem 16. Jahrhundert bis auf die Gegenwart in die Gärten und Parks Europas eingeführten Bäume un Sträucher. [List of trees and shrubs introduced into the gardens and parks of Europe from the 16th century to the present.] Mitteilungen der Deutschen Dendrologischen Gesellschaft 25: 129-201. (in German)

HALAREWICZ, A. – SZUMNY, A. – BACZEK, P. (2021): Effect of *Prunus Serotina* Ehrh. Volatile Compounds on Germination and Seedling Growth of *Pinus sylvestris* L. Forests 12: 846. https://doi.org/10.3390/f12070846

INSTAT (2003): GraphPad InStat, Version 3.06, for Windows, GraphPad Software, Inc., San Diego.

KOWARIK, I. (2010): Biologische Invasionen Neophyten and Neozoen in Mitteleuropa. [Biological Invasions. Neophytes and Neozoa in Central Europe.] Eugen Ulmer KG, Stuttgart, Germany. 492 p. (in German)

LEMMENS, R.H.E. – VAN TOL, G. (1977): De bestrijding van de Amerikaanse vogelkers, *Prunus serotina*. Een overzicht van de bestrijdingsmethoden. [Control of *Prunus serotina* – a survey of control methods.] Onkruldbestrijding 414: 441. (in Dutch with English summary)

MARQUIS, D.A. (1990): Black cherry *Prunus serotina* Ehrh. In: BURNS, R.M. – HONKALA, B.H. (eds.): Silvics of forest trees in the United States, Agriculture Handbook 654, Volume 2: Hardwoods. United States Department of Agriculture, Forest Service, Washington DC. 594-604.

MIHÁLY, B. (2017): On the authorisation of chemical treatments against invasive plants. In: CSISZÁR, Á. – KORDA, M. (eds.): Practical experiences in invasive alien plant control. Duna-Ipoly Natonal Park Directorate, Budapest. 39-40. https://oakprotection.eu/en/rosalia-handbooks-3-practical-experiences-invasive-alien-plant-control

MUYS, B. – MADDELEIN, D. – LUST, N. (1992): Ecology, practice and policy of black cherry (*Prunus serotina* Ehrh.) management in Belgium. Silva Gandavensis 57: 28-45. https://doi.org/10.21825/sg.v57i0.885

NEMES, V.E. (2015): Védekezési kísérletek értékelése a kései meggy (*Prunus serotina*) ellen. [Evaluation of control methods designed to suppress black cherry (*Prunus serotina*).] Diplomadolgozat, Nyugat-Magyarországi Egyetem, Erdőmérnöki Kar, Erdőművelési és Erdővédelmi Intézet, Sopron. 77 p. (in Hungarian)

NEMES, V.E. – MOLNÁR, M. (2017): Védekezési kísérletek a kései meggy (*Prunus serotina*) ellen. [Experiments for the control of black cherry (*Prunus serotina*).] In: CSIHA, I. – KAMADINÉ VÉGH, Á. – NAGY, A. (eds.): Alföldi Erdőkért Egyesület Kutatói Nap. Alföldi Erdőkért Egyesület, Kecskemét. 79-86. (in Hungarian) http://epa.oszk.hu/03400/03455/00001/pdf/EPA03455_kutatoi_nap_2017_079-086.pdf

OMSZ (2018): The weather of recent years – 2018. https://www.met.hu/eghajlat/magyarorszag_eghajlata/eghajlati_visszatekinto/elmult_evek_idojarasa/

OLSTHOORN, A. – VAN HEES, A. (2001): 40 years of Black Cherry (*Prunus serotina*) control in the Netherlands: lessons for management of invasive tree species. In: STARFINGER, U. – KOWARIK, I. (eds.): Biological invasions in Germany - A Challenge to Act? Contributions and results of a conference in Berlin. Federal Nature Conservation Agency, Bonn. 43-44.

OTRĘBA, A. – MARCISZEWSKA, K. – JANIK, D. (2017): Is cut-stump and girdling an efficient method of black cherry Prunus serotina Ehrh. Eradication? Folia Forestalia Polonica, Series A – Forestry 59 (1): 14-24. https://doi.org/10.1515/ffp-2017-0002

PÁSZTOR, L. – LABORCZI, A. – BAKACSI, ZS. – SZABÓ, J. – ILLÉS, G. (2018): Compilation of a national soil-type map for Hungary by sequential classification methods. Geoderma 311: 93-108. https://doi.org/10.1016/j.geoderma.2017.04.018

PETITPIERRE, B. (2008): Ecological and phylogeographical approach of a biological invasion: *Prunus serotina*, a case study. MSc thesis, University of Lausanne, Lausanne, Switzerland. 43 p.

PETITPIERRE, B. – PAIRON, M. – BROENNIMANN, O. – JACQUEMART, A.L. – GUISAN, A. – BESNARD, G. (2009): Plastid DNA variation in *Prunus serotina* var. *serotina* (Rosaceae), a North American tree invading Europe. European Journal of Forest Research 128: 431-436. https://doi.org/10.1007/s10342-009-0287-1

REINHARDT, F. – HERLE, M. – BASTIANSEN, F. – STREIT, B. (2003): Ökonomische Folgen der Ausbreitung von gebietsfremden Organismen in Deutschland. [Economic consequences of the spread of alien organisms in Germany.] J.W. Goethe-Universität Frankfurt, im Auftrag des Umweltbundesamtes, Forschungsbericht 201 86 211. 254 p. (in German)

ROLANDO, C.A. – BAILLIA, B.R. – THOMPSON, D.G. – LITTLE, K.M. (2017): The Risks Associated with Glyphosate-Based Herbicide Use in Planted Forests. Forests 8: 208. https://doi.org/10.3390/f8060208

SCHEPKER, H. (1998): Wahrnehmung, Ausbreitung und Bewertung von Neophyten – Eine Analyse der problematischen nichteinheimischen Pflanzenarten in Niedersachsen. [Perception, spread and assessment of neophytes – An analysis of the problematic non-native plant species in Lower Saxony.] Ibiden Verlag, Stuttgart. 246 p. (in German)

SMITH, D.M. – LARSON, B.C. – KELTY, M.J. – ASHTON, P. – MARK, S. (1997): The practice of silviculture: Applied forest ecology. John Wiley & Sons Inc., New York. 537 p.

SPAEH, I. – BALDER, H. – KILZ, E. (1994): Das Problem mit der Spätblühenden Traubenkirsche in den Berliner Forsten. [The problem with the black cherry in the forests of Berlin.] Allgemeine Forst- und Jagdzeitung 11: 234-236. (in German)

STARFINGER, U. (1990): Die Einbürgerung der Spätblühenden Traubenkirsche (*Prunus serotina* Ehrh.) in Mitteleuropa. [The naturalization of black cherry (*Prunus serotina* Ehrh.) in Central Europe.] Landschaftsentwicklung und Umweltforschung 69: 1-119. (in German)

STARFINGER, U. (1997): Introduction and naturalization of *Prunus serotina* in Central Europe. In: BROCK, J.H. – WADE, M. – PYSEK, P. – GREEN, D. (eds.): Plant invasions: studies from North America and Europe. Backhuys Publishers, Leiden. 161-171.

STARFINGER U. – KOWARIK, I. – RODE, M. – SCHEPKER, H. (2003): From desirable ornamental plant to pest to accepted addition to the flora? – the perception of an alien tree species through the centuries. Biological Invasions 5: 323-335. https://doi.org/10.1023/B:BINV.0000005573.14800.07

STARFINGER, U. (2010): NOBANIS – Invasive Alien Species Fact Sheet – *Prunus serotina*. https://www.nobanis.org/globalassets/speciesinfo/p/prunus-serotina/prunus-serotina.pdf

TERWEI, A. (2014): *Prunus serotina*. https://www.cabi.org/isc/datasheet/44360

TORRETTA, V. – KATSOYIANNIS, I.A. – VIOTTI, P. – RADA, E.C. (2018): Critical Review of the Effects of Glyphosate Exposure to the Environment and Humans through the Food Supply Chain. Sustainability 10 (4): 950. https://doi.org/10.3390/su10040950

TOSUN, J. – LELIEVELDT, H. – WING, T.S. (2019): A Case of 'Muddling Through'? The Politics of Renewing Glyphosate Authorization in the European Union. Sustainability 11 (2): 440. https://doi.org/10.3390/su11020440

VAN BRUGGEN, A.H.C. – HE, M.M. – SHIN, K. – MAI, V. – JEONG, K.C. – FINCKH, M.R. – MORRIS, J.G. JR. (1998): Environmental and health effects of the herbicide glyphosate. Science of The Total Environment 616-617: 255-268. https://doi.org/10.1016/j.scitotenv.2017.10.309

VAN DEN MEERSSCHAUT, D. – LUST, N. (1997): Comparison of mechanical, biological and chemical methods for controlling black cherry (*Prunus serotina*) in Flanders (Belgium). Silva Gandavensis 62: 90-109. https://doi.org/10.21825/sg.v62i0.848

VAN DEN TWEEL, P.A. – EISJACKERS, H. (1987): Black cherry, a pioneer species or 'forest pest'. Proceedings of the Royal Dutch Academy of Sciences 90: 59-66. https://www.cabi.org/isc/abstract/19890633189

VANDERHOEVEN, S. – DASSONVILLE, N. – MEERTS, P. (2005): Increased topsoil mineral nutrient concentrations under exotic invasive plants in Belgium. Plant Soil 275: 169-179. https://doi.org/10.1007/s11104-005-1257-0

VANHELLEMONT, M. – CALLE, B. – ELIET-ELIET, O. – SCHELFHOUT, S. – VAN DE VRIJVER, E. – VERHEYEN, K. (2008): Bestrijding van Amerikaanse vogelkers in Vlaanderen: stand van zaken. [Control of black cherry in Flanders: state of the art]. Bosrevue 25: 1-5. (in Dutch)

VERŐ, GY. – CSÓKA, A. (2017): Experience of invasive alien plant management in the steppe oak woods of Nagykőrös and in Turjánvidék. In: CSISZÁR, Á. – KORDA, M. (eds.): Practical experiences in invasive alien plant control. Duna–Ipoly National Park Directorate, Budapest. 79-84. https://oakprotection.eu/en/rosalia-handbooks-3-practical-experiences-invasive-alien-plant-control

WEIN, K. (1930): Die erste Einführung nordamerikanischer Gehölze in Europa. [The first introduction of North American Woody Plants to Europe.] Mitteilungender Deutschen Dendrologischen Gesellschaft 42: 137-163. (in German)

WRONSKA-PILAREK, D. – MACIEJEWSKA-RUTKOWSKA, I. – BOCIANOWSKI, J. – KORZENIEWICZ R. – LECHOWICZ, K. – HAUKE-KOWALSKA, M. (2022): Does the Reaction of Inflorescences and Flowers of the Invasive *Prunus serotina* Ehrh. to Various Herbicides Give Hope for Elimination of This Species from Polish Forests? Forests 13 (1): 21. https://doi.org/10.3390/f13010021